

levels appropriate for the microphone input 115, and was designed so it can use power from the phone.

A voltage divider made from (fixed-value) resistors was used to attenuate the signal from the speaker-out 114 output, of the sound card 116, on its way to the microphone preamplifier of the phone. It was found that the negative terminal of the preamplifier did not need to be connected to this voltage divider because the phone internally connects this negative terminal to one terminal of its speaker driver. Since the coupling device includes a resistor 512 between that terminal of the driver and the ground of the sound card, the needed connection is already (indirectly) supplied.

The voltage divider extends from one of the stereo channels (either the left or the right channel) of the speaker-out jack of the sound card 116 to the ground of the same jack. The other channel is not used. The positive input of the phone's microphone preamplifier is connected to a point between the two resistors of the voltage divider. Thus, the signal from the sound card 116 is attenuated before the preamplifier. The phone internally provides the connection between the negative terminal of the preamplifier and the terminal of the phone's speaker driver that is connected to the In 1 (-) 502 input of the coupling device.

The coupling device was connected, almost directly to the phone's DC power plug. As the DC power provided by the plug was rough a filter was added, and voltage regulated between this plug and the coupling device. The phone may provide filtering and voltage regulation internally and some internal point for powering to the coupling device may be able to be connected. The 33 Ω ohm resistor and the capacitors shown in figure 8 provide the filtering. The voltage regulator (for example, it can be ML 7805A) 810 maintains its output at five volts above the regulators reference terminal. Two resistors function as a voltage divider to raise the reference potential about 4.1 volts above the negative terminal so the output is about 9.1 volts above the negative terminal.

The phone's speaker driver 193 is connected to the inputs In 1 (-) 502 and In 2 (+) 504. The resistor R6 510 prevents the absence of the speaker from

significantly affecting the operation of the speaker driver. High-pass filters (capacitor C1 514 and, resistor R3 516) filter away DC offsets. The operational amplifiers A1 518 and A2 520 function as voltage followers to provide isolation from the differential amplifier that is at their outputs. This differential amplifier (including A3, 522) actually provides the attenuation down to levels appropriate for the microphone inputs of the sound card 116. The output of this differential amplifier passes through another high-pass filter that provides some isolation from the sound card.

Since three voltages power this coupling device, but the phone provides two voltages, amplifier A4 524 is part of an averager that supplies a middle voltage. Additional capacitors (four of them) are connected to the power inputs to diminish the effects of transients. The example used a quad op amp chip (LM324N) 526 to provide all four operational amplifiers.

The foregoing has described the principles, preferred embodiments and modes of operation of the present invention. However, the invention should not be construed as being limited to the particular embodiments discussed. The above-described embodiments should be regarded as illustrative rather than restrictive, and it should be appreciated that variations may be made in those embodiments by workers skilled in the art without departing from the scope of the present invention as defined by the following claims.